Designing and Building a Pair of Scintillating Bubble Chambers for WIMPs and Reactor CEvNS

An Overview

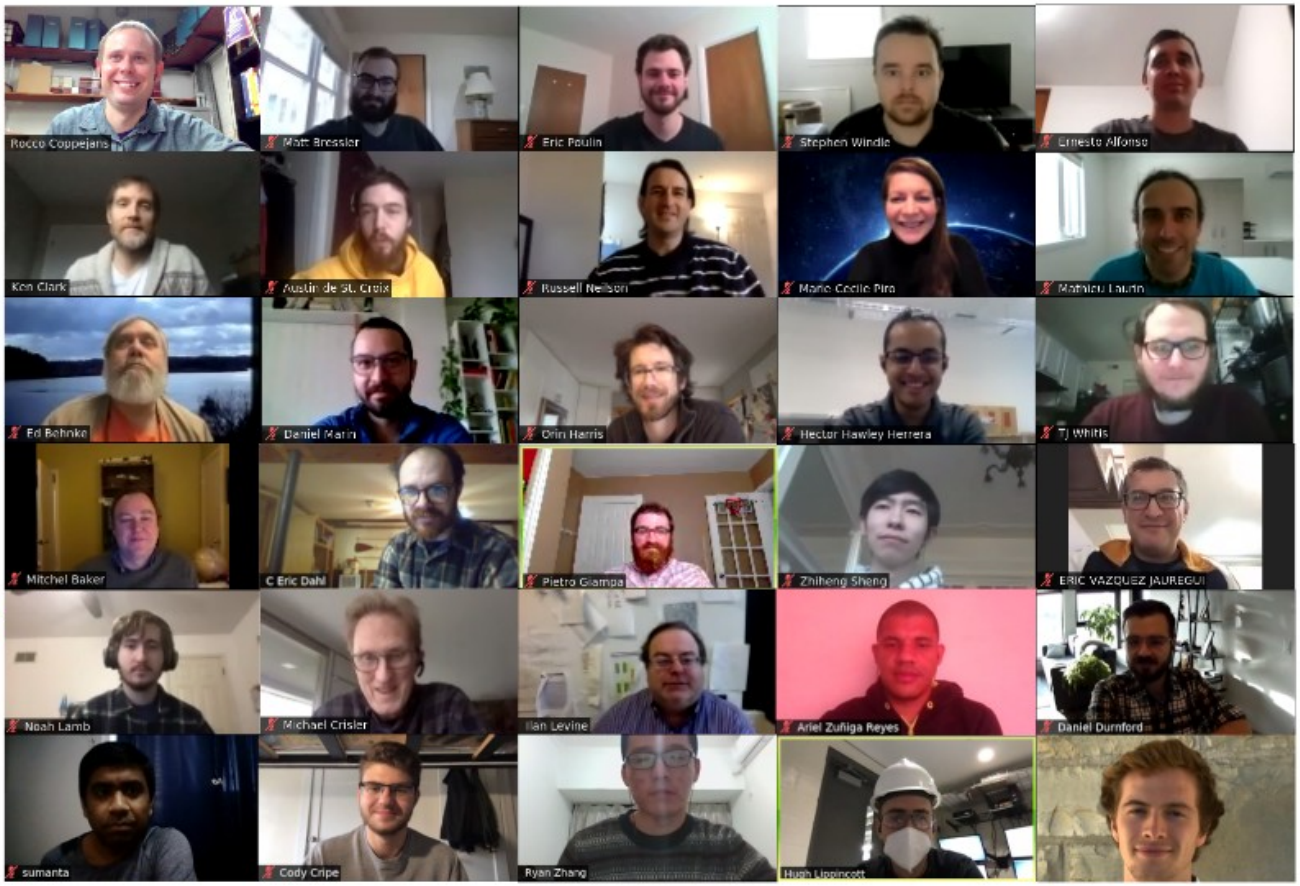
Rocco Coppejans
On behalf of the SBC Collaboration
CPAD, March 2021

Northwestern
Department of Physics and Astronomy

COFI
COLEGIO DE FISICA FUNDAMENTAL E INTERDISCIPLINARIA DE LAS AMERICAS

Fermilab

The Scintillating Bubble Chamber Collaboration



Northwestern University

- **Eric Dahl**
- Rocco Coppejans
- Zhiheng Sheng
- Aaron Brandon
- David Velasco
- Ari Sloss
- Mahebub Khatri
- Dishen Wang
- Shishir Bandapalli

Queen's University

- **Ken Clark**
- Hector Hawley
- Patrick Hatch
- Austin De St Croix

University of Alberta

- Marie-Cécile Piro
- Carsten Krauss
- Daniel Durnford
- Sumanta Pal
- Youngtak Ko
- David Biaré
- Mitchel Baker

SNOLAB

- Pietro Giampa
- Eric Poulin

Université de Montréal

- Mathieu Laurin

Northeastern Illinois University

- Orin Harris

Pacific Northwest National Laboratory

- Chris Jackson

Universidad Nacional Autónoma de México

- Eric Vázquez-Jáuregui
- Ernesto Alfonso-Pita
- Ariel Zuniga-Reyes
- Daniel Lámbarri

Drexel University

- Russell Neilson
- Matt Bressler
- Noah Lamb
- Stephen Windle

Indiana University South Bend

- Ilan Levine
- Ed Behnke
- Cody Cripe

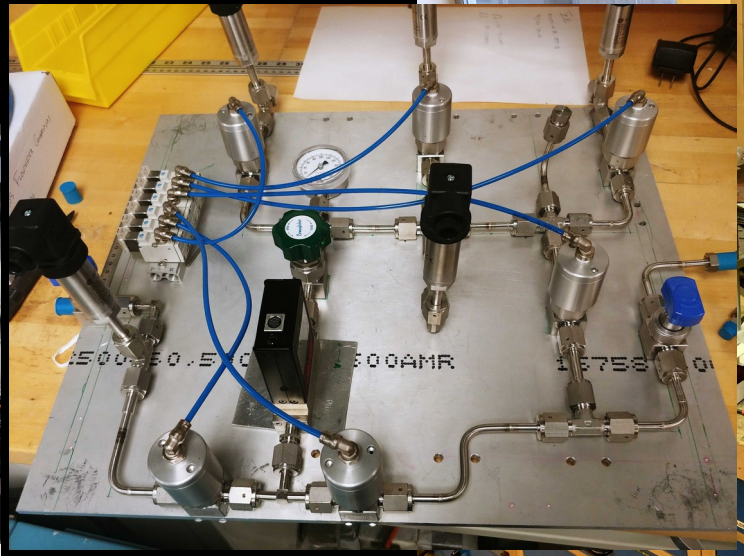
UC Santa Barbara

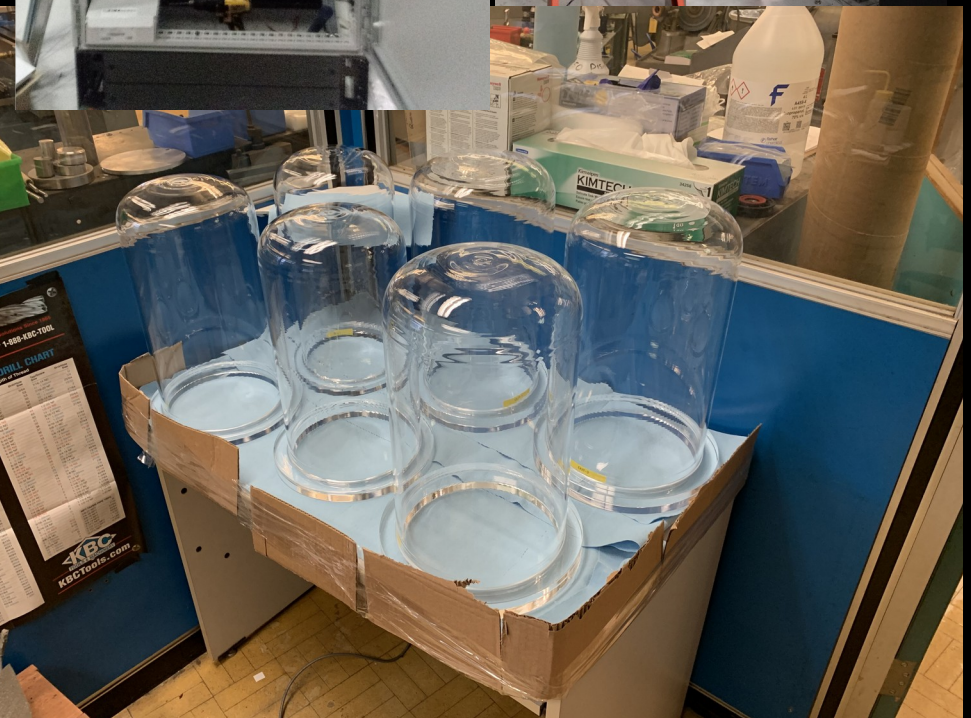
- Hugh Lippincott
- TJ Whitis
- Runze Zhang

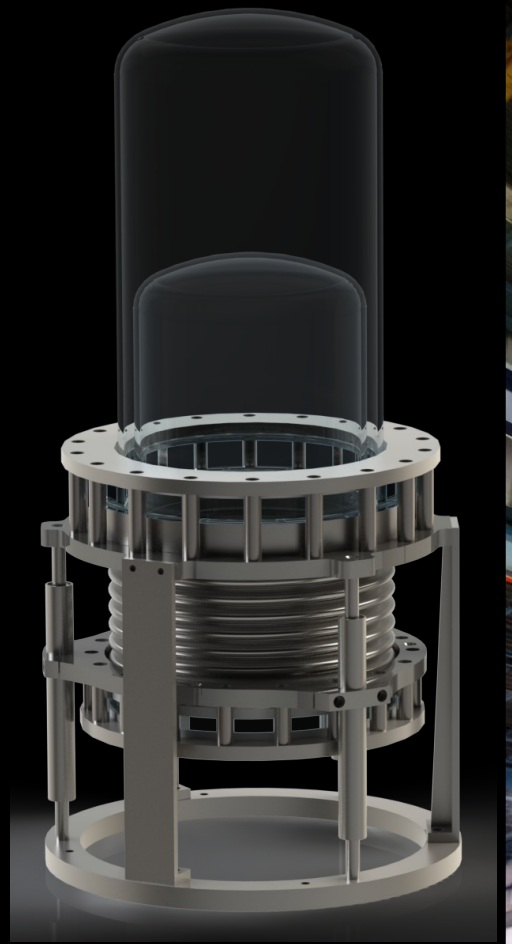
Fermilab

- Mike Crisler

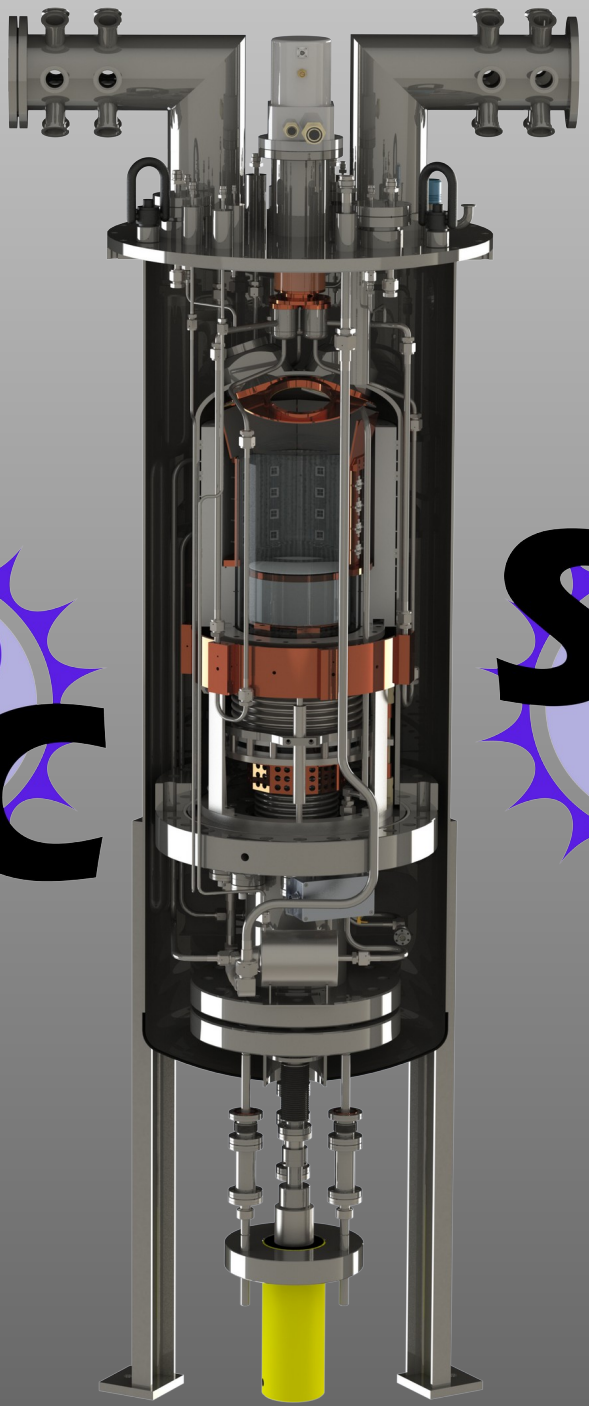
In My Previous Talk

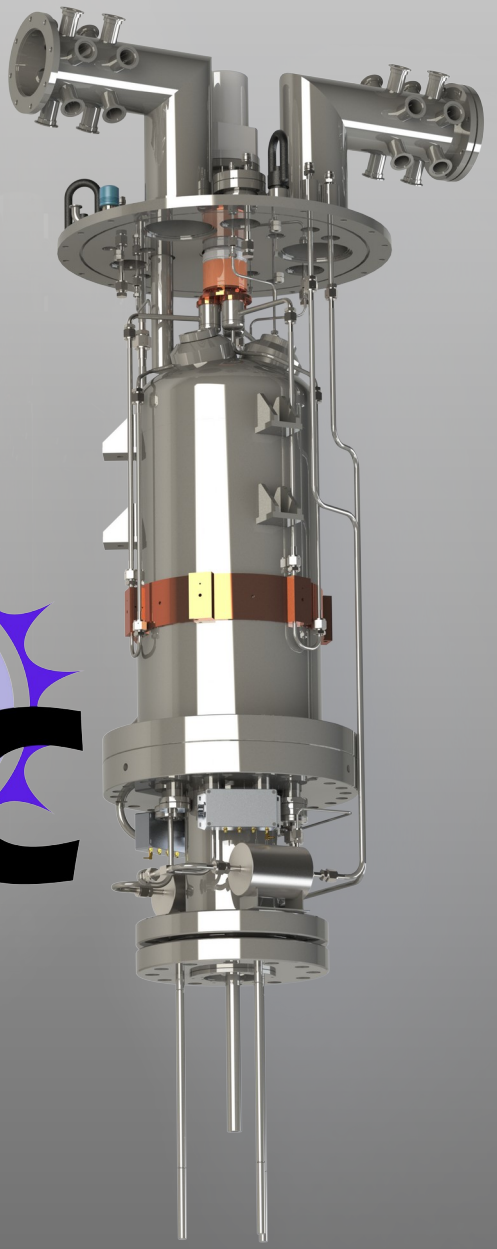




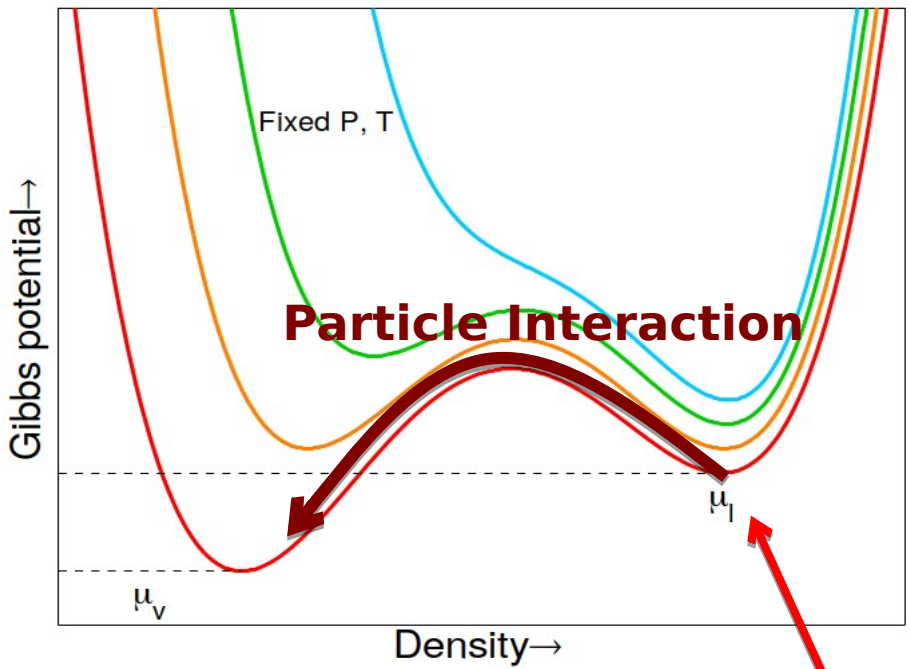


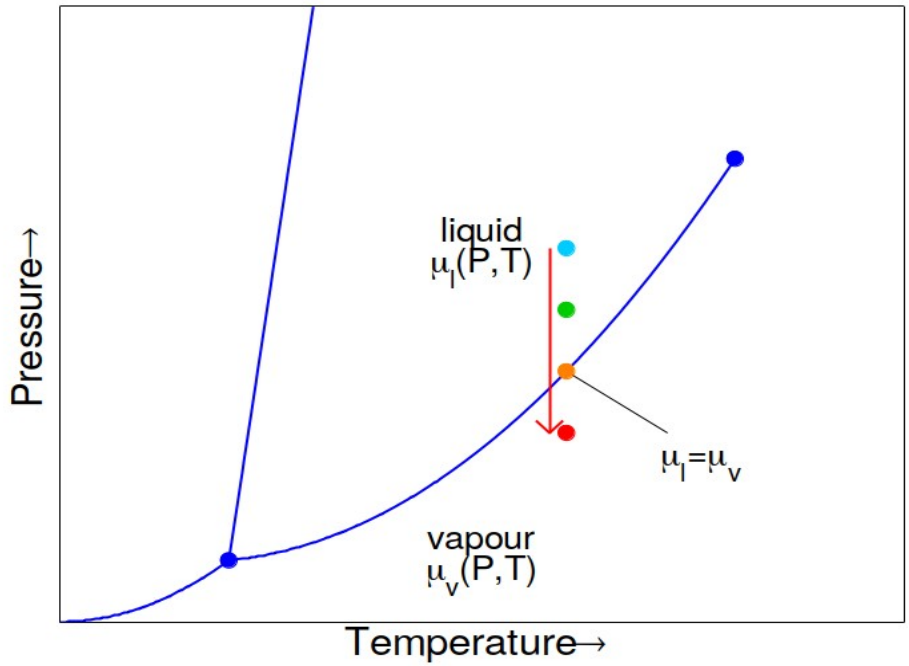
The SBC





Bubble Chamber Thermodynamics: A Metastable state





Superheated Liquid

Scintillating Bubble Chamber (SBC)

Combine the **electron recoil discrimination** of bubble chambers with the **event-by-event energy resolution** of scintillation detectors

What Does an Event Look like?

- Temperature control
- Pressure control
- Timing links:
  Bubble imaging,
  Acoustics &
  Scintillation

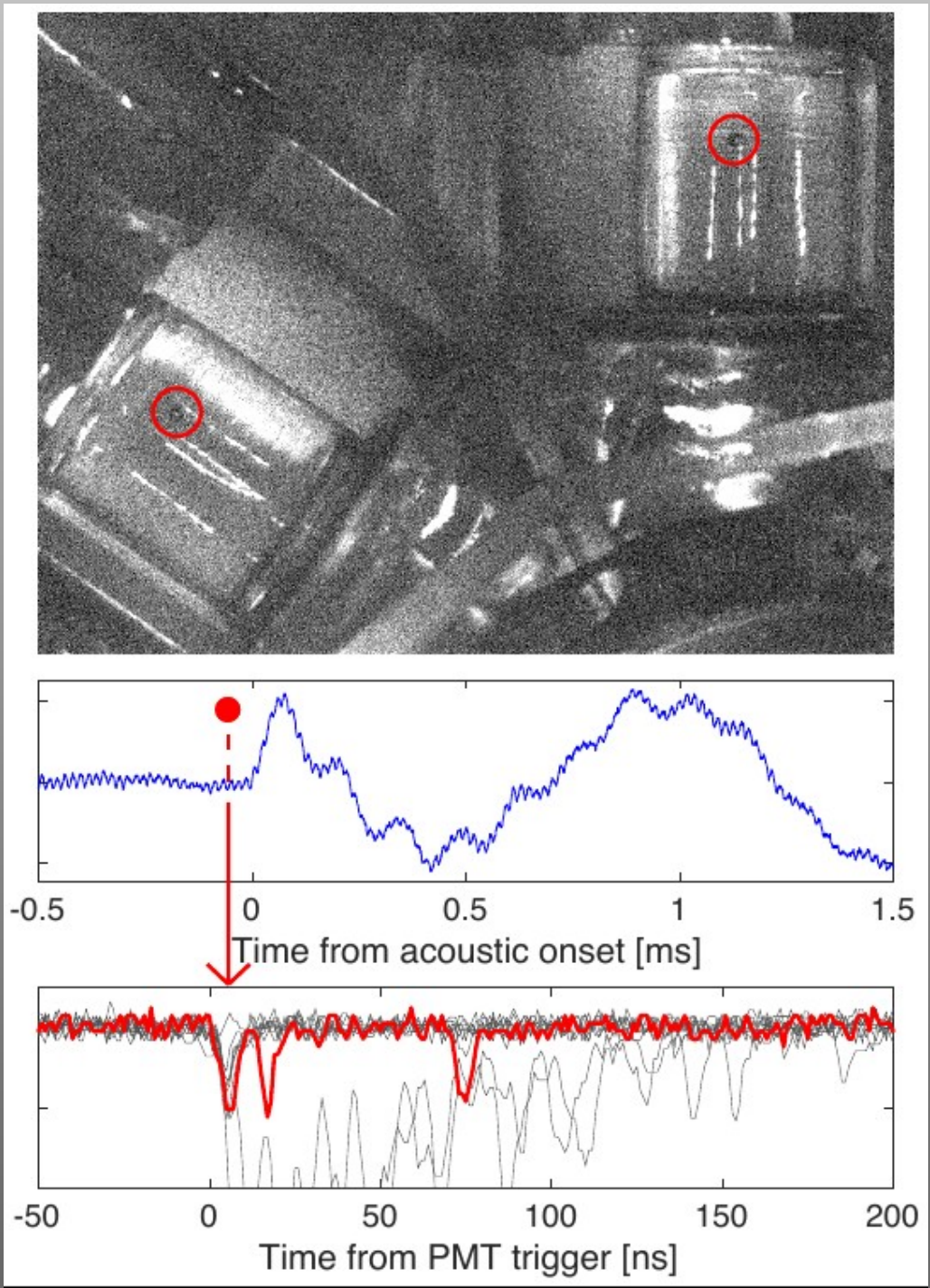
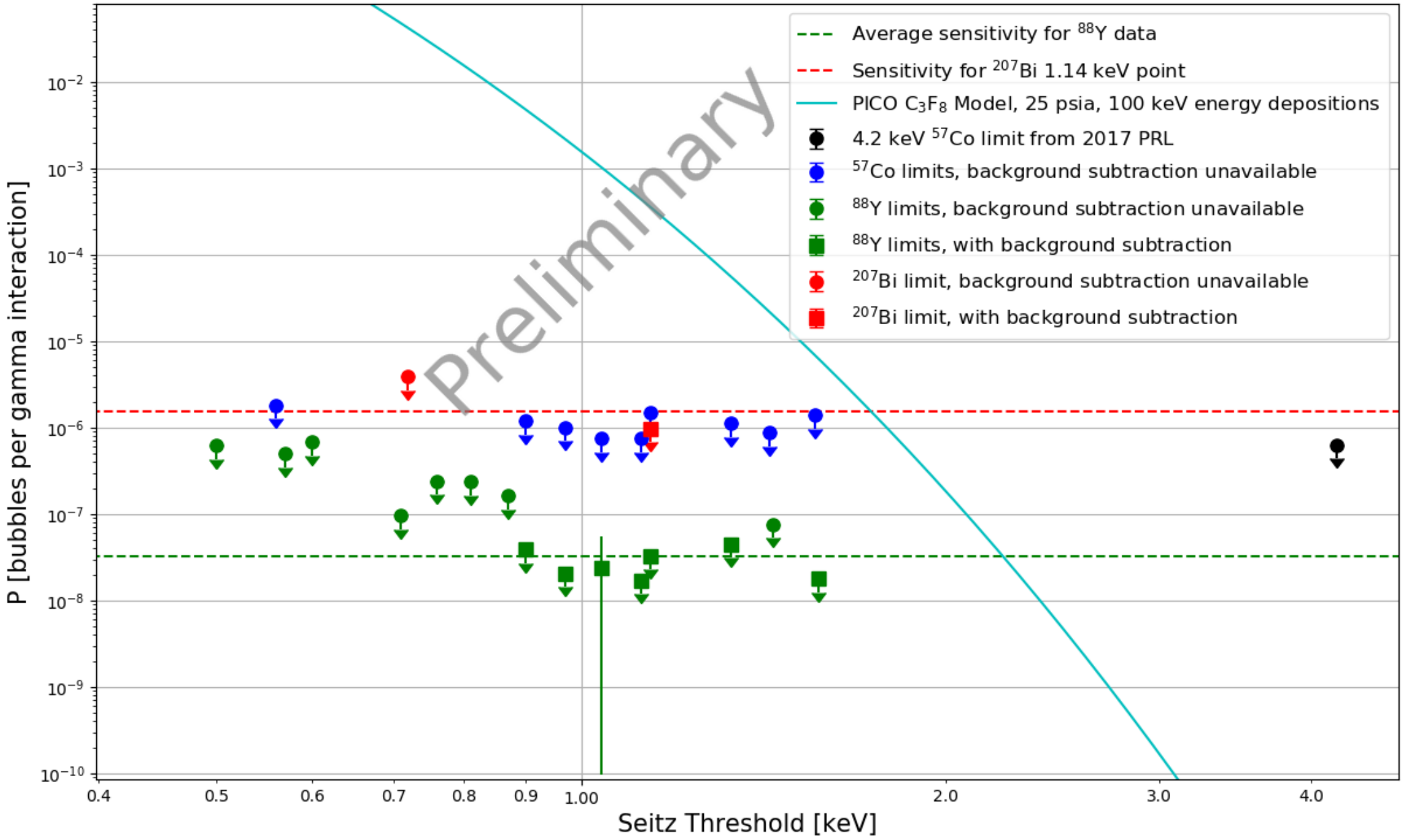


Image from: Baxter D., et al., Phys. Rev. Lett. 118, 231301 (2017) https://arxiv.org/abs/1702.08861

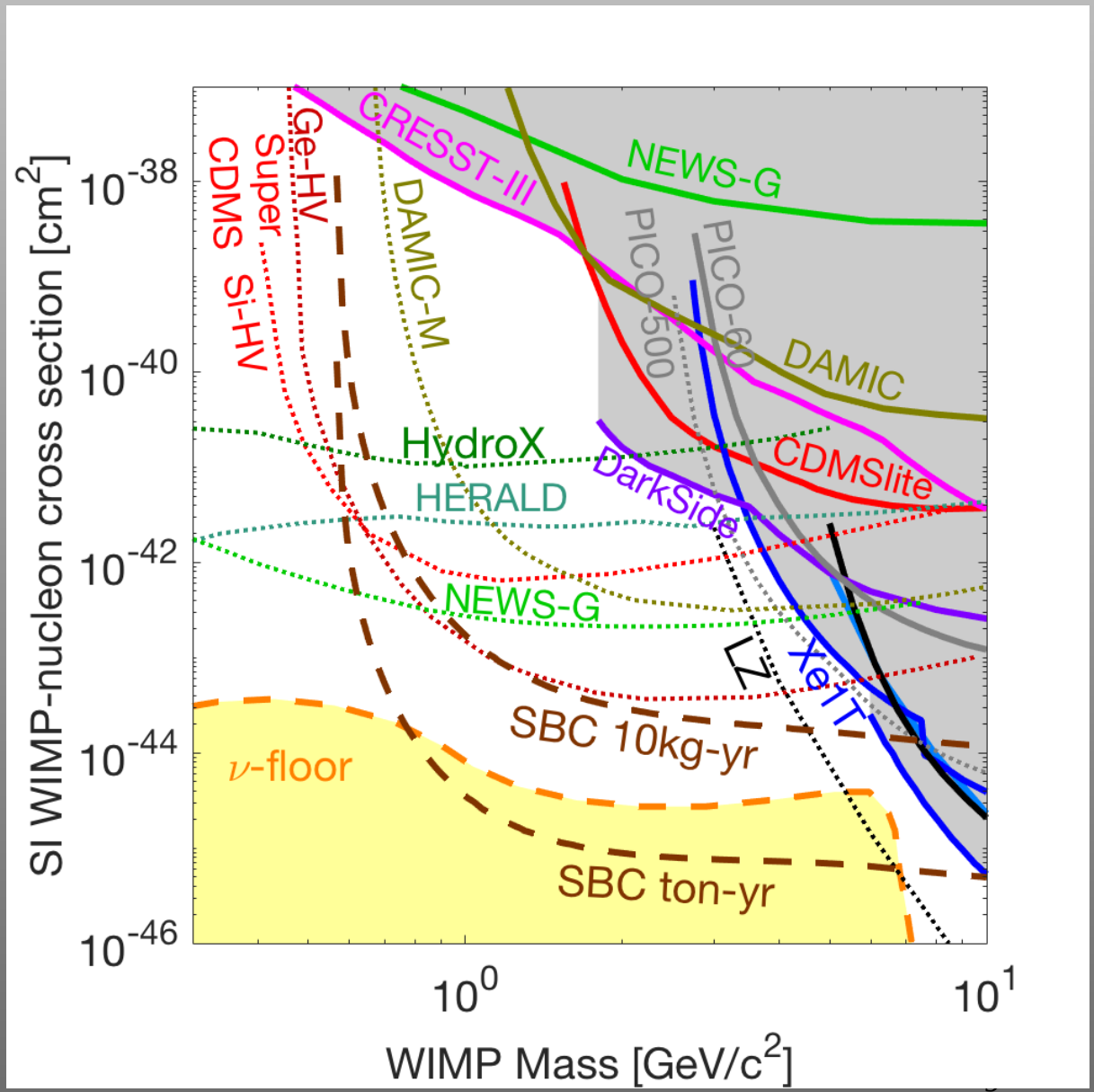
Electron Recoil Discrimination



See talk by M. Bressler

DM Detection

- Reaching neutrino floor @ 1GeV requires **ER discrimination at 100eV**
- This has not been achieve yet
- SBC is the only easily scalable technology that might achieve this



Predicted CEvNS Sensitivity

O(0.7) CEvNS events / kg-day @ 1MW reactor

High statistics searches for non standard neutrino interactions

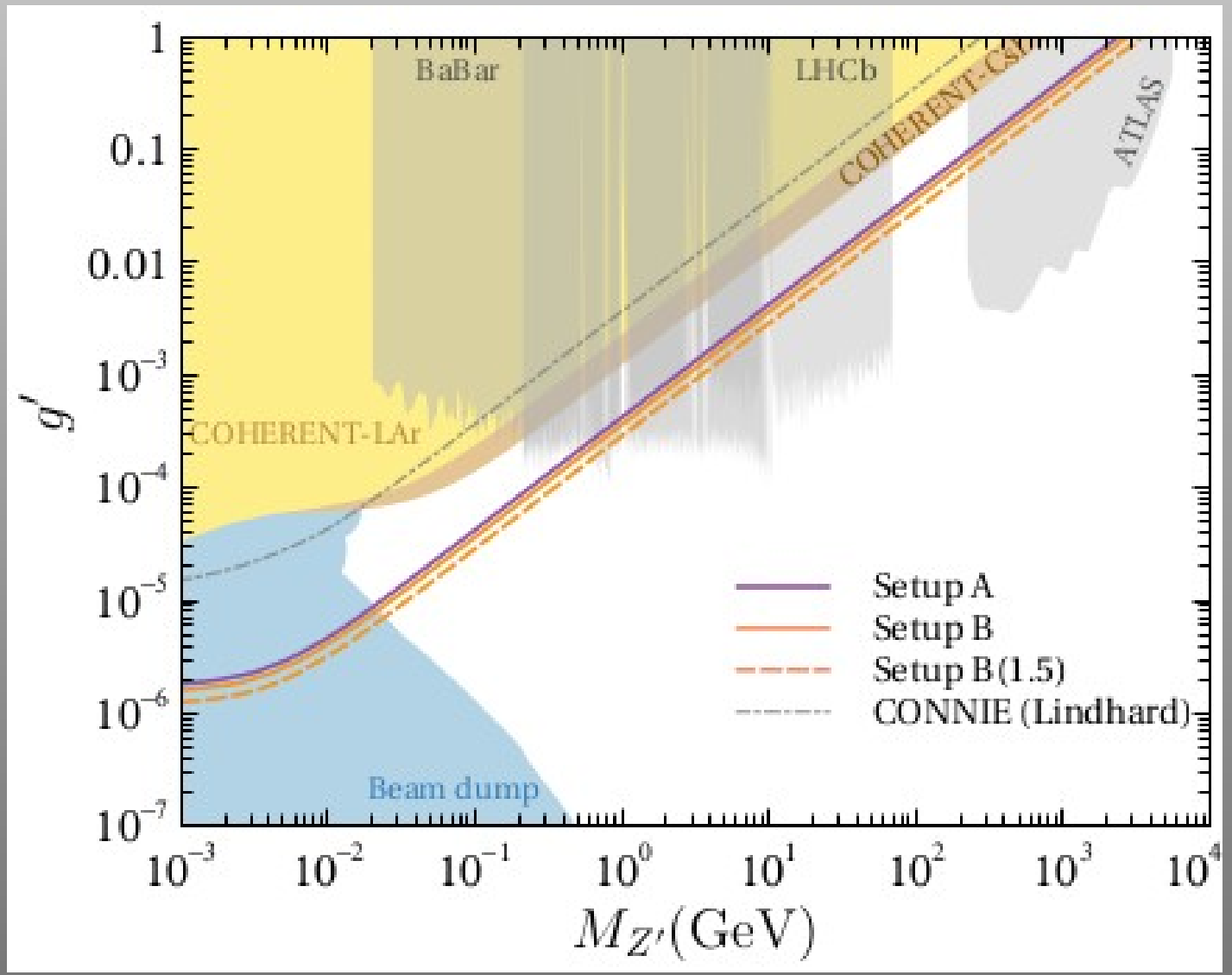


Image from: Flores L. J. et al., 2021, Physics reach of a low threshold scintillating argon bubble chamber in coherent elastic neutrino-nucleus scattering reactor experiments, Submited https://arxiv.org/abs/2101.08785

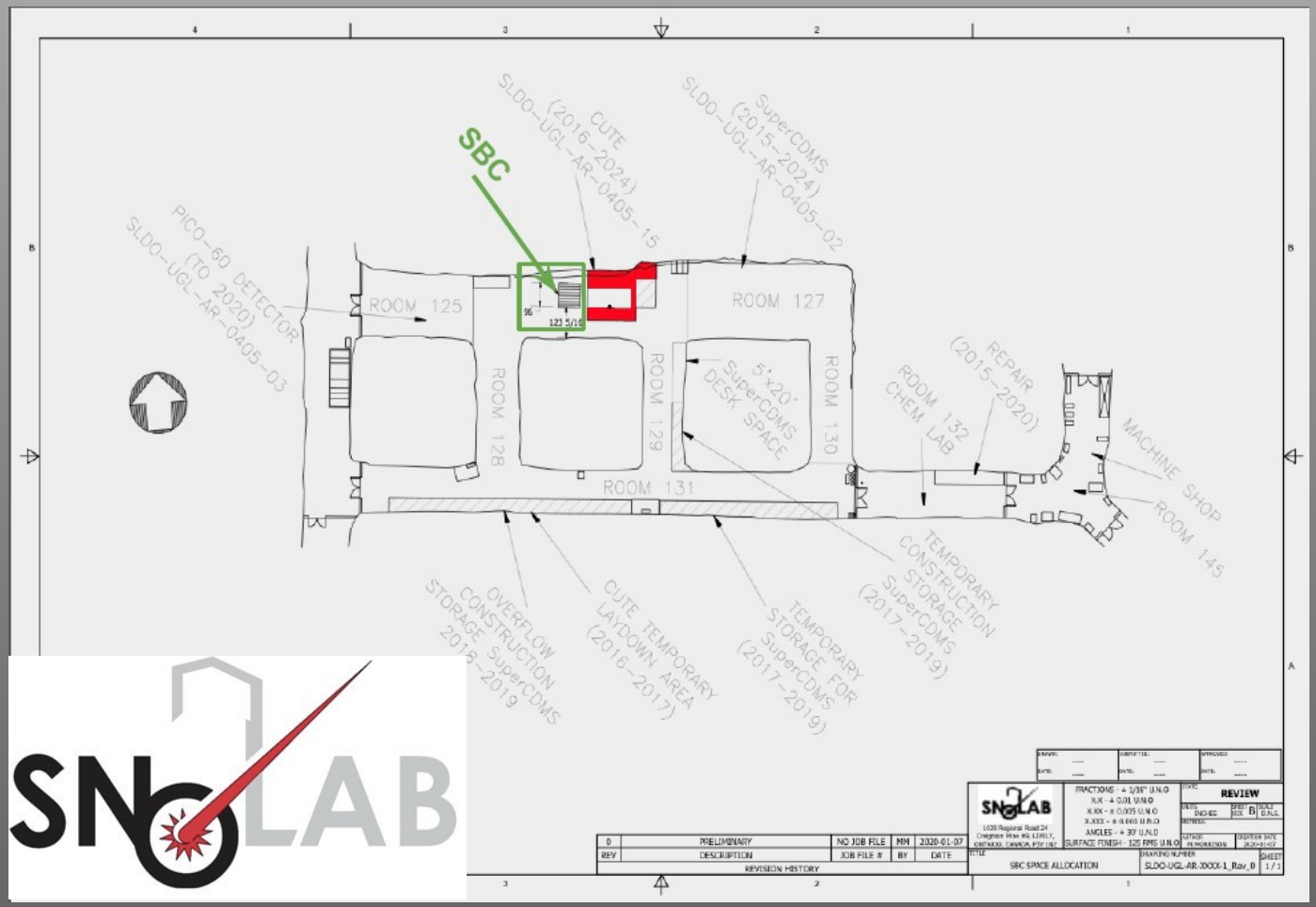
SBC-Fermilab Objectives

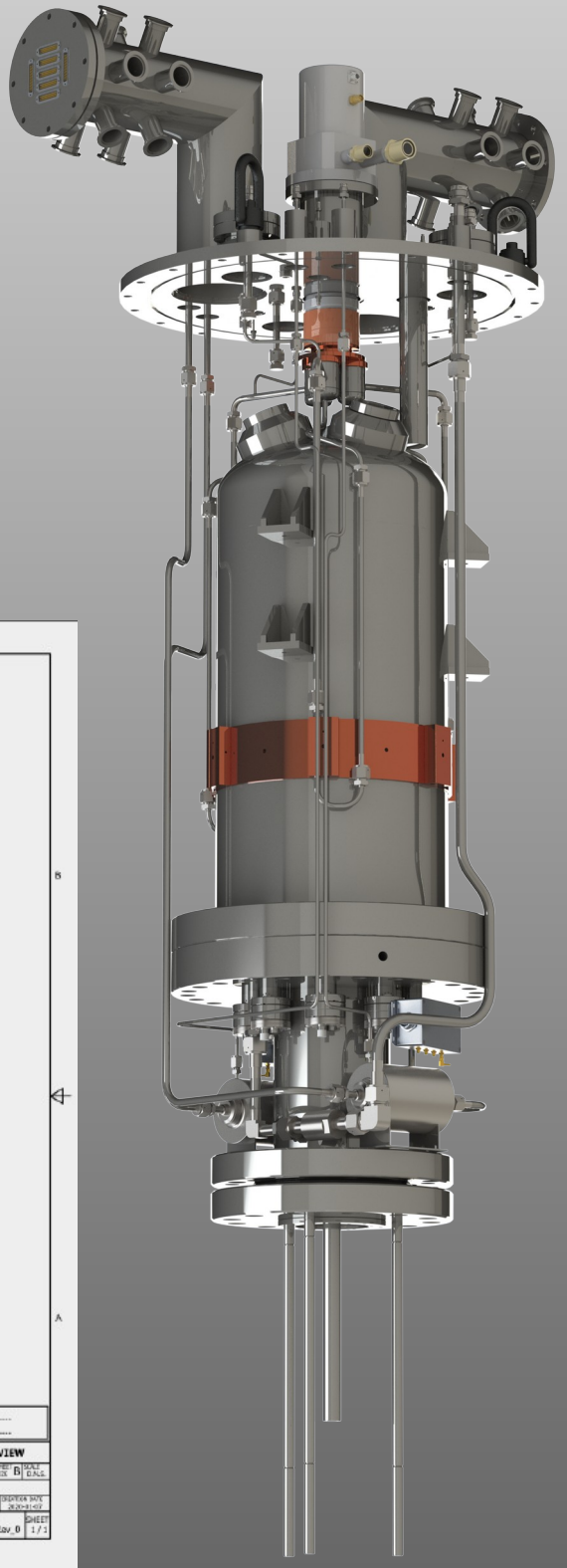
- Demonstrate **scalability**
- Determine the **bubble nucleation probability for electron recoils**
- Determine **nuclear recoil sensitivity**

Fermilab

SBC-SNOLAB Objectives

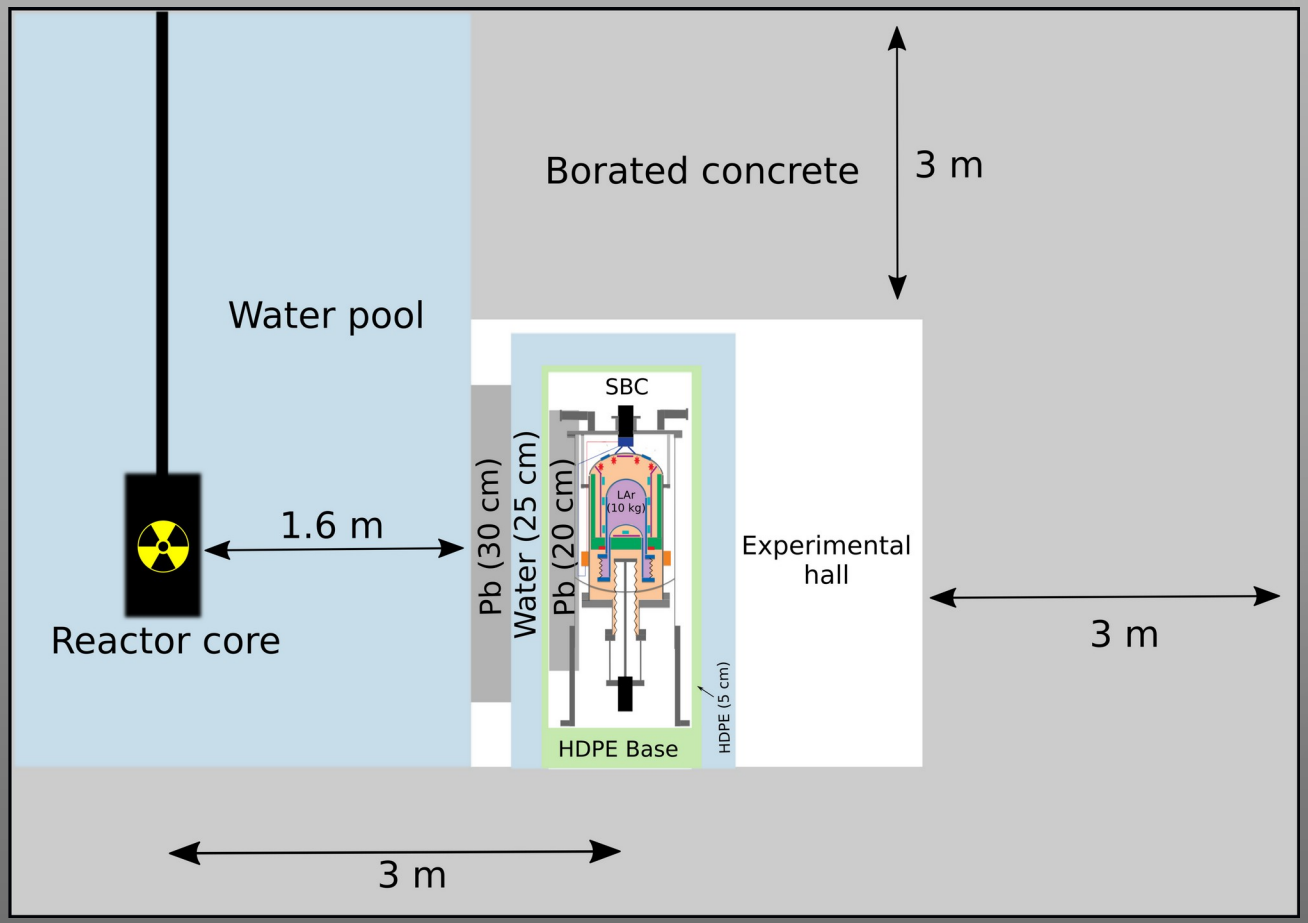
- Search for **DM @ SNOLAB**
- GW1 approval received Oct 2019

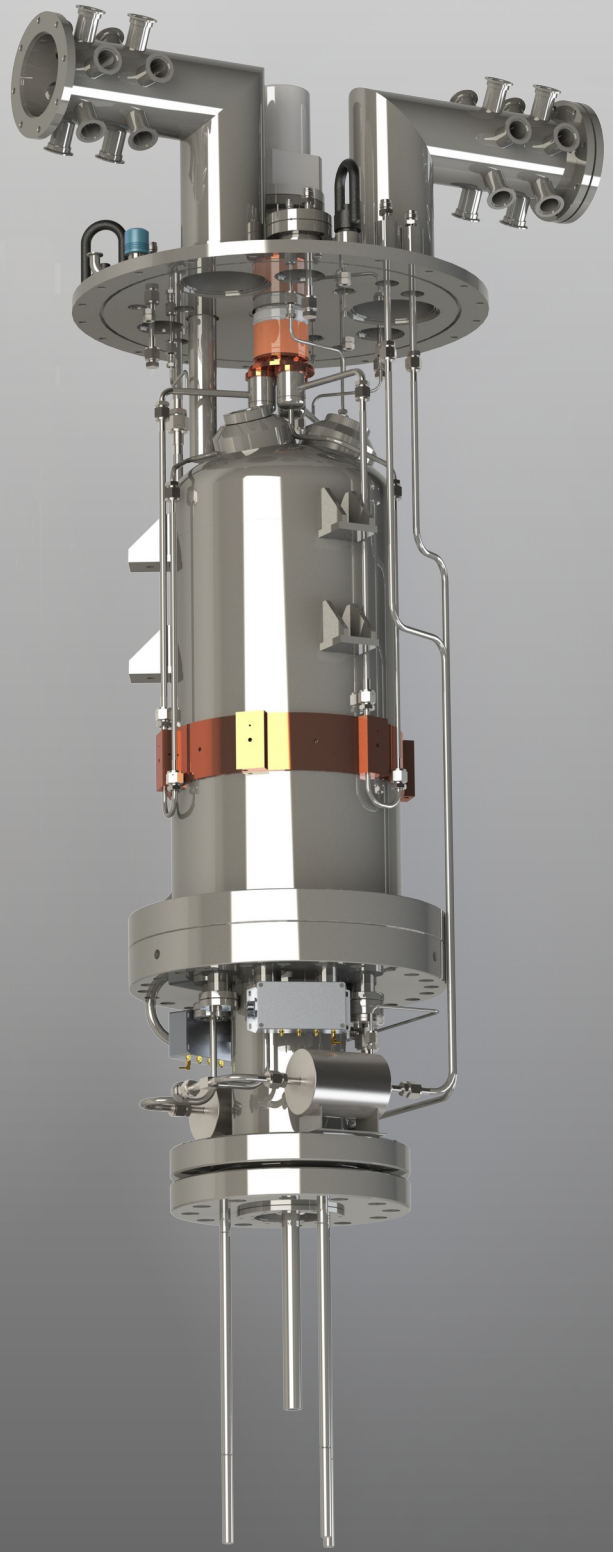




SBC-CEvNS Objectives

Study CEvNS at a nuclear reactor





Conceptual design of the configuration at the ININ experimental hall
https://arxiv.org/abs/2101.08785

Timelines

- **SBC-Fermilab**
  - Assembly and commissioning:
    - Present → 2022
  - Science operation:
    - 2022 → 2024

- **SBC-SNOLAB**
  - Construction = SBC-Fermilab + 1 year
  - DM search:
    - 2023 & 2024

- **SBC-CEvNS**
  - Preliminary site investigations are underway
  - Experimental program follows calibration at FNAL

Thank You